3.32 RESULTS FOR FIRE ENABLE/DISABLE

Unlike other subsystems simulated by *RADGUNS*, gun firing does not occur every scan period. The subroutine FIRCON, which is called every scan, synchronizes the firing of the guns with the rest of the simulation. After the radar system has established autotrack, the fire-control computer (FCC) calculates the aiming solution for the guns and determines if the target will be within range after a predicted time of flight (TOF) for a fired round. The gun turret, or mount, is moved to the commanded azimuth and elevation angles by the gun servos, and when a "within range" solution is achieved, the FCC activates the fire light for the operator. Simulation of firing bursts at the target is accomplished in subroutine SHOOT, and each burst is followed by a short rest period to cool the gun barrels. SHOOT keeps track of the fire light and the gun to determine the proper action for the gun to take (fire or rest) during the current scan period.

Flight path data recorded during range testing was used to drive the RADGUNS model and produce FIRE LIGHT ON and OFF event times. These were compared to event times recorded during the testing as a function of range from the threat for the various offsets and target speeds. As shown in Table 3.32-1, correlation of events was statistically significant and better during egress from the threat than during ingress. Differences in range were not investigated, but could be attributed to differences in muzzle velocity settings in the FCC as well as operator delays in acquiring and establishing autotrack on those runs. A delay of less than five seconds would account for the largest difference between modeled and measured ranges for FIRE LIGHT ON.

TABLE 3.32-1. Summary of Results for FIRE ENABLE / DISABLE.

Data Source	Major Conditions	Statistical MOEs	Results
WEST-XI	Fighter-size aircraft Level flight passes at Low altitude	F test for means F test for variances Mann-Whitney U test	All within 95% confidence interval (0.05 significance level)
		Correlation (graphical and numerical)	0.7771 for ingress 0.9838 for egress

3.32.1 Assessment - Case 1

Assessment Description

<u>Test Data Description</u>. Flight testing against the WEST-XI system was conducted during the fall of 1993 at an Eglin AFB test range. Normal tracking instrumentation was used to provide data files containing TSPI and time markers when events (i.e., FIRE LIGHT ON or OFF) occurred. These data files were examined to establish test conditions, flight path parameters, and target ranges at the desired event times. Flight path data (TSPI) files were input to *RADGUNS* via the BLUMAX option along with target RCS and VA data and runs were made to produce event times for comparison with the test data. Parameters of interest for Fire Light performance, during both ingress and egress, were range to the target and target velocity at the time of the event.

<u>Validation Methodology</u>. Statistical methods were used to compare the data samples and characterize differences between them. The ***F*** test (two-sample for means and variances) was deemed suitable for the small (< 30) sample size, and the non-parametric Mann-Whitney U test was used as a validity check on the ***F*** test results, because it is independent of population distribution. Both ***F*** tests and the U test were conducted using the 95%

confidence interval as the established MOE. Scatter charts were also used to graphically assess correlation coefficients of range test to model produced data.

Results

Ingress (FIRE LIGHT ON) matched pairs are illustrated in Figure 3.32-1, where target ranges at FIRE LIGHT ON are shown at various velocities. FIRE LIGHT ON is a function not only of target velocity but also geometry between the threat and the target, which accounts for variations in range at nearly identical velocities.

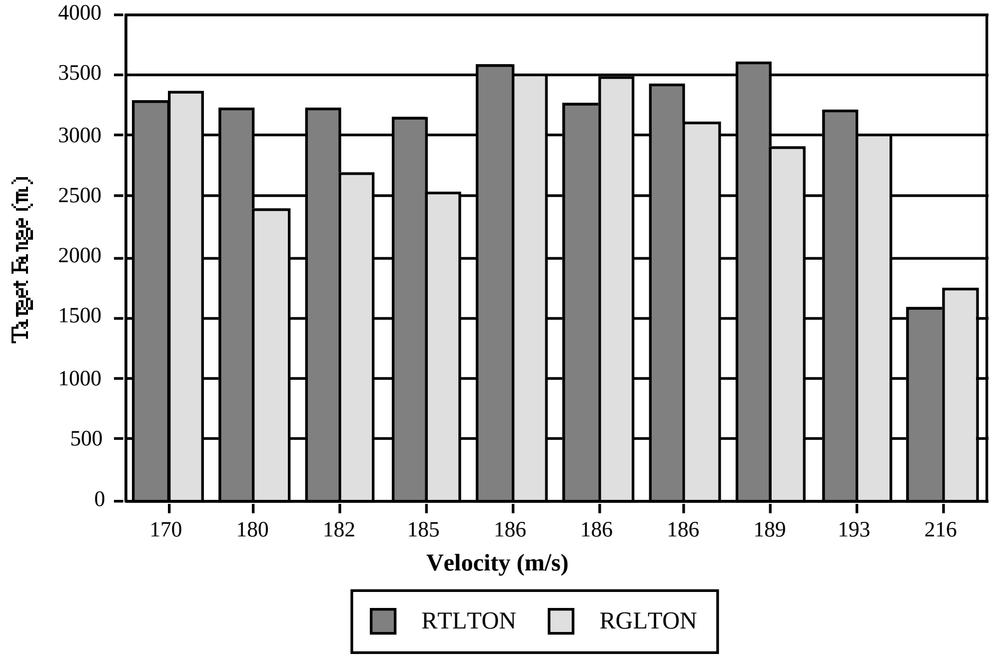

FIGURE 3.32-1. FIRE LIGHT ON vs. Velocity.

The statistical comparisons of these pairs are listed in Table 3.32-2. The F test for small samples (< 30) is used as the parametric statistic for both mean and variance. The non-parametric Mann-Whitney U test was used to test the null hypothesis (i.e., that both sets of data are from the same population). F tests are one-tailed tests; the U test is two-tailed. All three statistics were within the critical range at the 0.05 significance level (95% confidence interval), so the null hypothesis could not be rejected.

TABLE 3.32-2. Statistical Parameters for Ingress FIRE LIGHT ON Events.

Statistic	Critical Range	Computed Value	Probability
F-Test Two-sample for Means	$F_C < 4.4139$	$F_M = 1.2771$	0.2733
F-Test Two-sample for Variances	$F_C < 3.1789$	$F_V = 1.0781$	0.4563
Mann-Whitney U test	$_C$ <1.96	z_U =	0.0668

Figure 3.32-3 depicts a scatter chart of the matched event pairs on their respective axes. The correlation coefficient for the ingress event pairs was 0.7771, which is indicative of the relatively loosely grouped pattern shown in the figure.

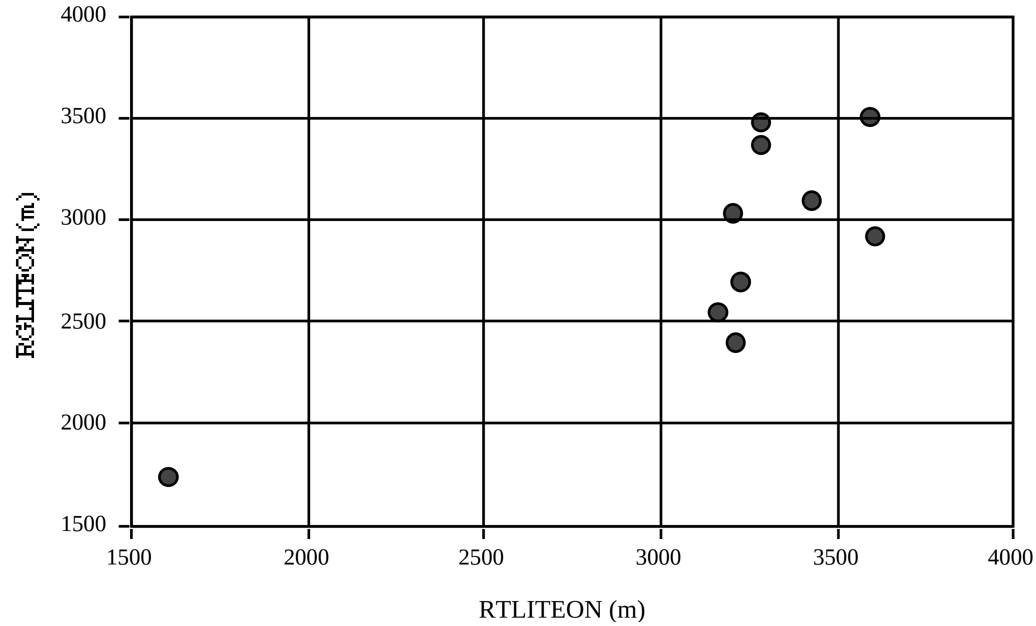

FIGURE 3.32-2. FIRE LIGHT ON Scatter Chart.

FIRE LIGHT OFF event pairs during egress are shown in Figure 3.32-3. Both geometry and velocity again influenced each FIRE LIGHT OFF event, but differences between measured and modeled events were much smaller than for ingress.

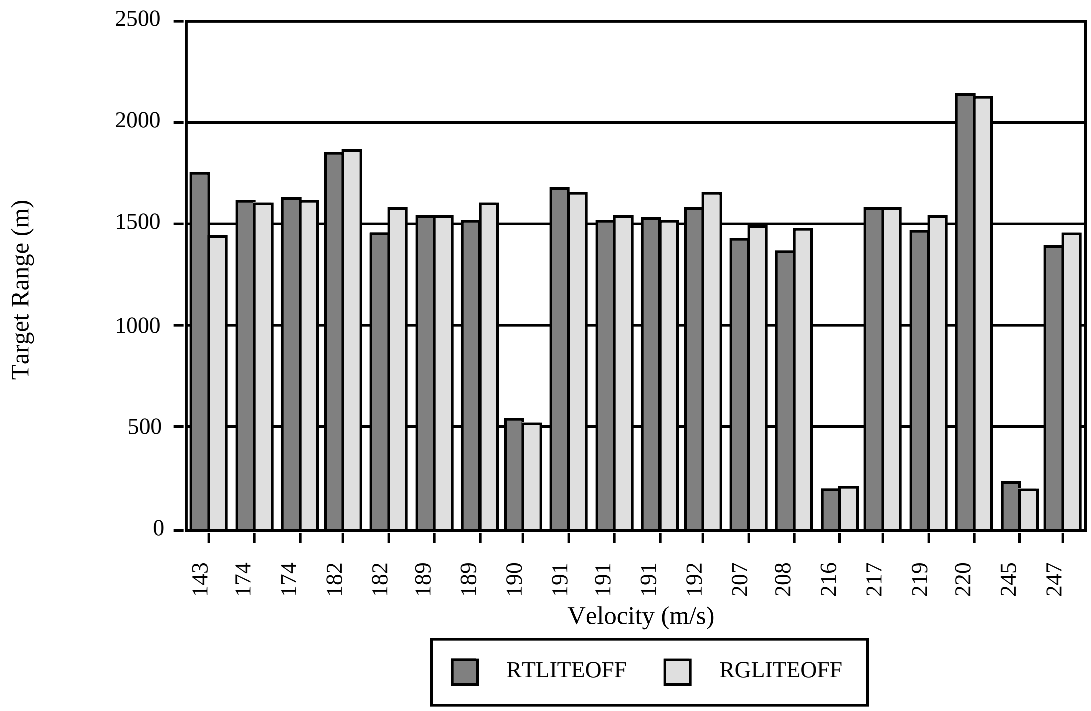

FIGURE 3.32-3. FIRE LIGHT OFF vs. Velocity.

Table 3.32-3 lists the statistical parameters of these matched pairs, which are better matched than the ingress cases.

TABLE 3.32-3. Statistical Parameters for Egress FIRE LIGHT OFF Events.

Statistic	Critical Range	Computed Value	Probability
F-Test Two-sample for Means	F_C < 4.0982	F_M = 0.0063	0.9372
F-Test Two-sample for Variances	F_C < 1.8224	F_V = 1.0212	0.4820
Mann-Whitney U test	$_C$ <1.96	z_U = 0.4869	0.3121

Figure 3.32-4 is the scatter chart for the egress data pairs. The high degree of correlation apparent in the figure is substantiated by a correlation coefficient of 0.9838.

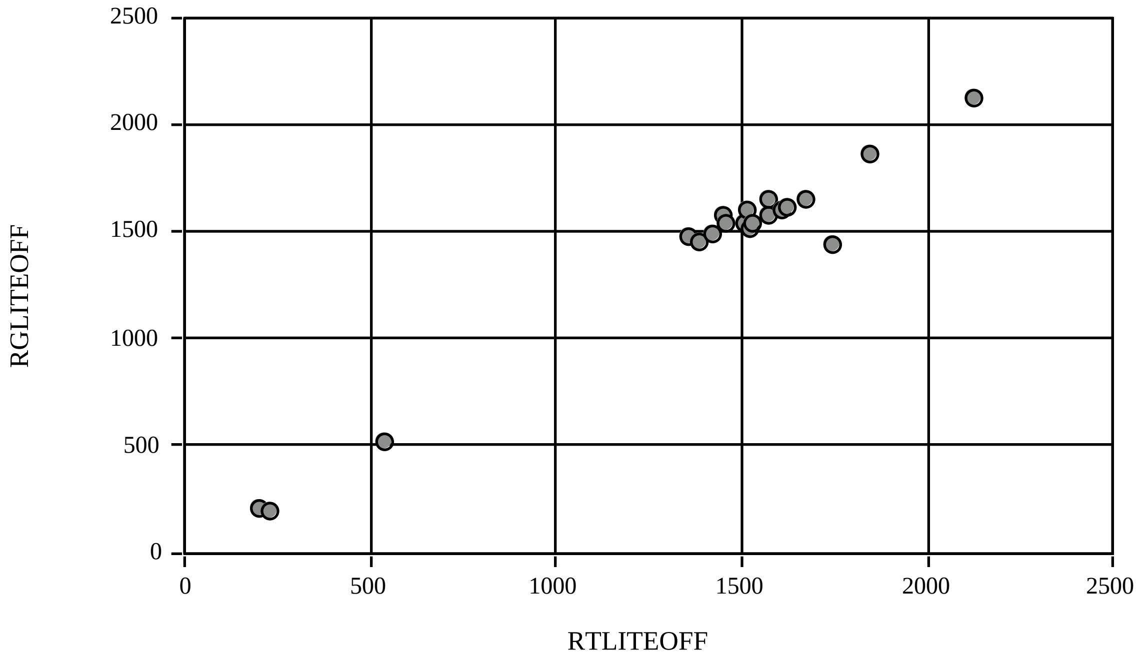

FIGURE 3.32-4. FIRE LIGHT OFF Scatter Chart.

Conclusions

Even though the sample sizes used in this analysis were small (10 for ingress and 20 for egress), correlation among event pairs was almost perfect for the disable events and would probably be improved for the enable events by obtaining more samples. Results of this assessment suggest that the *RADGUNS* calculation of the Fire Enable/Disable solution compares well with test cases and is valid for the 23-mm gun system. Calculations for other gun systems are made via the same algorithm, but TOF estimates are based upon different muzzle velocities and enable/disable tests are made against different tactical ranges. No problems in the implementation of this FE were indicated by the model produced data or its comparison to the test data. Therefore, the sizes of engagement envelopes predicted by the model should agree with those of actual AAA threats.